# Quantum-coherent Transport in Quantum Hall Devices

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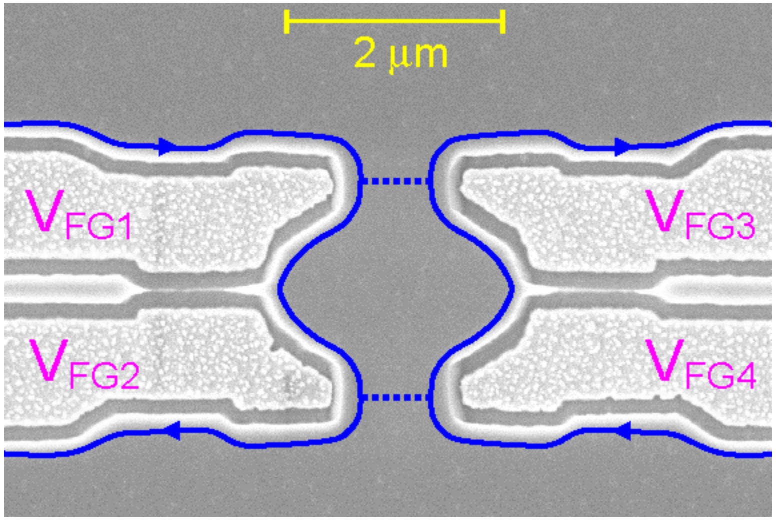
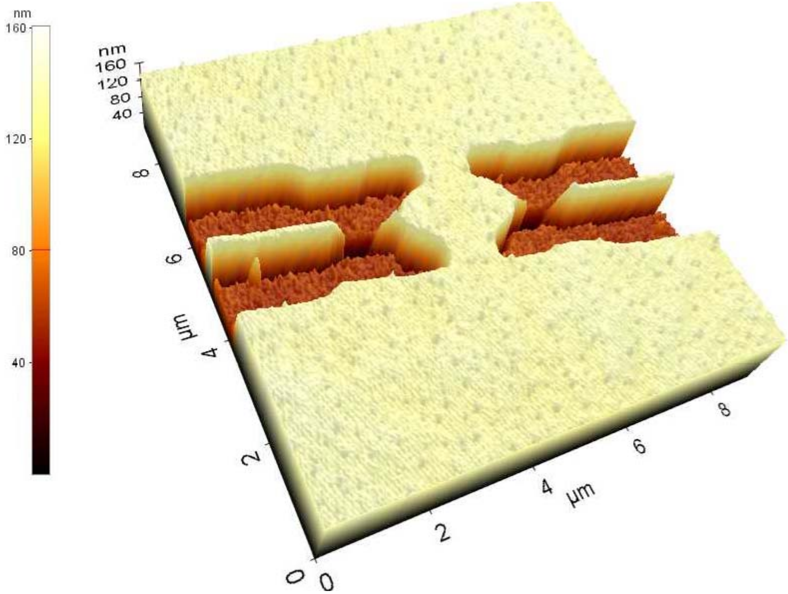
We have fabricated an electron Fabry-Perot interferometer, which operates in very high magnetic fields and at very low temperatures. Early results show characteristic quantum interference patterns for both electrons and fractionally-charged Laughlin quasiparticles. A scanning electron microscope (SEM) and an atomic force microscope (AFM) images of a typical device are shown. Gate metal is deposited in etched trenches because electrons are some 350 nm below the semiconductor surface. Blue lines show electron paths in a high magnetic field, the dotted lines show quantum tunneling paths. Four front gates, $V_{FG1\text{-}4}$, are used to control tunneling and the symmetry of the device (we also have a "back gate", $V_{BG}$, on the bottom of the device).



In quantum mechanics electrons have wave-like properties, and can interfere similar to the light waves. Unlike light, electrons are electrically charged particles, and the electrical current carried by electrons is used to carry information in all modern electronic equipment, such as computers and communications gear. We would like to explore the quantum interference of electrons in novel ways, for example, to be used in a quantum computer. There are several difficulties, however. One of the largest is that the quantum electron wave is affected by thermal and electromagnetic random fluctuations, so that the interference pattern is destroyed and the quantum information carried by the electrons is lost. What's left is the ordinary "classical" information (a tiny fraction of quantum) that is used in today's electronics. We are working to find ways to make the quantum nature of the electron waves more robust, specifically exploring use of novel electron devices that work in a very high magnetic field and at low temperatures (so-called "Quantum Hall effect"). The low temperature just by itself helps to preserve electron wave. A high magnetic field strongly affects motion of electrons, and helps limit the random fluctuations. Additionally, in the special case of the "Fractional Quantum Hall effect" electrons are known to move collectively (many together, in a coordinated way), and have certain peculiar properties that can be used as a working principle of novel electronic devices thought to be advantageous for quantum computation. The first order of business is to figure out how to make such quantum-coherent electron devices perform with negligible effects of random "decoherence". "Coherence" means that all information in the quantum electron wave is preserved.

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**Education:**

Two graduate (Wei Zhou, Xin Chen), one undergraduate (Jia G. Li, female) and one postdoc (Dr. Fernando E. Camino) worked on research supported by this NSF-DMR Grant.

Prof. Goldman serves on a Graduate Admissions and Physics Colloquium Committees, hosts colloquium and seminar speakers, gives talks to prospective and visiting students, and is a member of the Program Committee of the International Conference on Low Temperature Physics-24 (2005).

**Outreach:** A web site http://quantum.physics.sunysb.edu/ contains a number of pictures of equipment and facilities, and recent research presentations. It is also used in education as the web site of classes taught by Prof. Goldman. It averages a thousand hits per month from all over the world.

**Societal Impact:**

The ability to quantum-coherently transport electrons and fractional quasiparticles is a very powerful technique and may lead to the development of new kinds of electronic devices, including quantum computers.